CALFED BAY-DELTA PROGRAM
TECHNICAL SERVICES BRANCH

DRAFT

-- ISOLATED FACILITY --

HYDRAULIC ANALYSIS
OF
INCISED CANAL CONFIGURATION

JULY 1998

CALFED
BAY-DELTA
PROGRAM

D-010994

HYDRAULIC ANALYSES
OF
INCISED CANAL CONFIGURATION

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1. INTRODUCTION

1.1 Background

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This report addresses engineering issues associated with Alternative III of the CALFED alternatives for the Sacramento-San Joaquin Delta. Among other facilities, Alternative III includes an Isolated Delta Conveyance Facility that would divert water from the Sacramento River near Hood and deliver directly into Clifton Court Forebay. ~~to the intakes of the State Water Project (SWP)~~. This report was prepared as part of the Storage and Conveyance Component Refinement Task of the CALFED Bay-Delta program (CALFED). CALFED's mission is to develop a long-term comprehensive plan that will restore the ecological health and improve water management for beneficial uses of the San Francisco Bay/Sacramento-San Joaquin Delta (Bay-Delta) system.

This report summarizes the principal features and some of the environmental considerations of constructing a hydraulically isolated conveyance facility through the Sacramento-San Joaquin Delta. This information will be used to provide an updated estimate of the cost of construction of such a facility. A cost estimate is not provided in this report, however. The general location of the Isolated Delta Conveyance Facility (Isolated Facility) is shown on Figure 1.1. The objectives of the Isolated Facility evaluation are to: 1) provide an updated estimate of the capital cost of constructing this facility within the range expected if the project were to be constructed today, and 2) enable CALFED to compare this project against other projects that might be considered as part of a long-term CALFED solution strategy.

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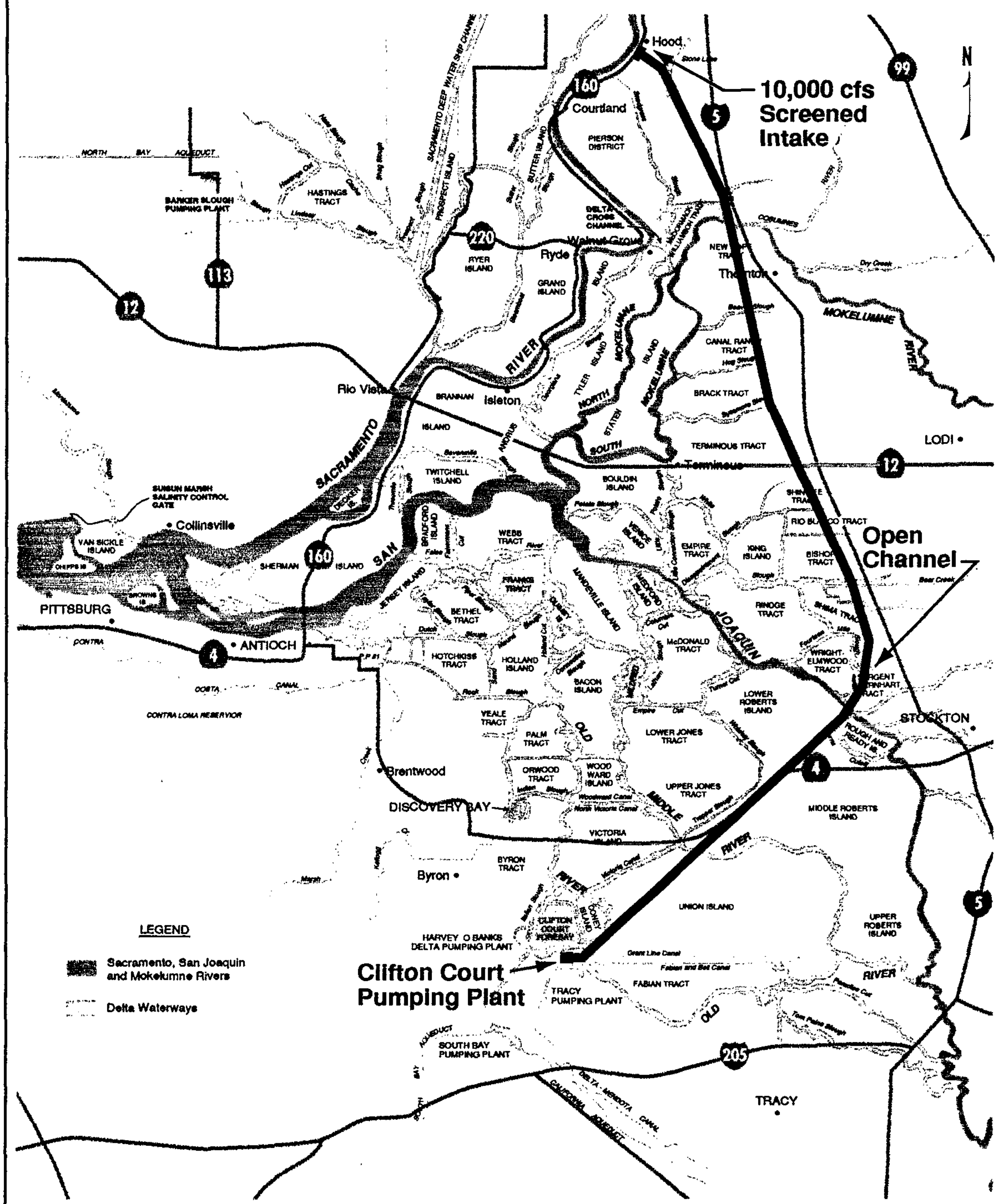
FIGURE 1.1

Isolated Faciliy Alignment



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A number of studies have been made of a proposed conveyance system that would transport water from the Sacramento River to the intakes of the state and federal water project canals in the southern Delta. The conveyance system was initially conceived as the Peripheral Canal.

In October 1964 the U.S. Bureau of Reclamation (Reclamation) published a report titled *Reconnaissance Estimate, Delta Division — Peripheral Canal.* Design studies for the Peripheral Canal were undertaken by the California Department of Water Resources (DWR) during the later part of the 1960 and early 1970s. The design was sufficiently advanced to allow DWR to publish a *Draft Environmental Impact Report - Peripheral Canal Project* in August 1974.

CALFED continued the study of the concept of this type of water conveyance facility, but as an isolated facility, as reported in the September 1995 California Department of Water Resources (DWR) report titled *Cost Estimate — Isolated Transfer Facility,* and the 1996 CALFED Bay-Delta Program Report titled *Preliminary Evaluation of 5,000 cfs Isolated Transfer Facility Using Buried Pipeline*. The studies performed by CALFED, DWR, and Reclamation were reviewed and modified in this evaluation.

A preliminary evaluation of the environmental considerations associated with the Isolated Facility is included in an appendix this report. Fish, wildlife, plant, and cultural resources that could be affected have been described and potential impacts have been identified in various CALFED, Reclamation, and DWR studies. The information for the evaluation of environmental considerations was gathered from existing literature and databases.

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1.2 Project History

Development of the Delta began in the 19th century. Reclamation of Delta marshlands began in the 1850s; by the 1930s, nearly the entire Delta had been reclaimed into intensively farmed islands. Ocean salinity intrusion to the interior of the Delta was observed as early as the 1840s and was recognized as a potential problem to water supplies. Since that time, there have been numerous studies of methods to control salinity intrusion and otherwise improve the management of the water resources of the Delta.

In 1960, California voters approved the Burns-Porter Act to assist in the financing of the State Water Project (SWP). This Act authorized Delta facilities "... for water conservation, water supply in the Delta, transfer of water across the Delta, flood and salinity control, and related functions." In the same year, DWR proposed the Delta Water Project to serve as the Delta water facility of the SWP. This plan, however, was met with stiff opposition from Delta water users, boaters, fish and wildlife agencies, and other Delta interests. Consequently, DWR and the California Department of Fish and Game (CDFG) established the Delta Fish and Wildlife Protection Study and the Interagency Delta Commission (with Reclamation and the U.S. Army Corps of Engineers) to develop a mutually acceptable plan for the Delta. In 1965, the Interagency Delta Commission recommended the Peripheral Canal as the water transfer plan. The Peripheral Canal would convey water from the Sacramento River at Hood to the State and federal pumping plants in the south Delta. The Peripheral Canal would eliminate interference with Delta waterways and would release freshwater to Delta channels to maintain water quality and mitigate impacts to fish.

In 1966, DWR designated the Peripheral Canal as the Delta Facility of the SWP. In 1969, the Department of the Interior (Interior) adopted Reclamation's Peripheral Canal Feasibility Report, which recommended that the project be a joint-use facility of the SWP and the Central Valley Project (CVP) with costs shared equally. Although the Peripheral Canal was supported by two subsequent administrations, the facility was never constructed, partly for the following reasons: Although the Interior and Reclamation supported the facility, federal funding was never forthcoming. In addition, there was continuing fear of and controversy over the cost of the canal and of potential harm from improper operation. Some water users believed that water could be obtained at a lower cost. Also, some Delta interests feared that in times of water shortage, institutional, statutory, and contractual guarantees for Delta protection could be changed or ignored and water needed to protect the Delta would be exported.

In 1975, DWR began to reassess the Peripheral Canal, DWR Bulletin 76 (July 1978), identified and considered numerous alternative water transfer facilities. In 1980 Senate Bill (SB) 200 was passed by the State Legislature and signed by the Governor. This bill authorized the Peripheral Canal and provided specific guarantees to protect the Delta and to meet the water needs of the SWP through the year 2000. However, SB 200 was subjected to a statewide referendum vote in June 1982, and California voters did not approve the project.

The rejection of SB 200 by the voters did not alleviate the need to increase the amount of water transferred across the Delta and at the same time meet the water needs of the Delta itself. Since that time, alternative water transfer plans for the Delta have been investigated by DWR and other agencies. In 1983, DWR published *Alternatives for Delta Water Transfer*, which examined four alternatives for improving the water transfer system. The alternatives examined in the DWR report included a dual transfer facility that included an isolated conveyance facility (similar to the Peripheral Canal) and improvements to channel conveyance capacities in the north and south Delta. This dual conveyance configuration did not pass the selection process used in that investigation.

In the process of developing a long-term comprehensive plan to restore the ecological health of and improve water management in the Bay-Delta, CALFED has selected to evaluate an Isolated Conveyance Facility similar in configuration to the Peripheral Canal. The purpose of this report is to provide an updated engineering evaluation of an isolated conveyance facility. This will enable CALFED to compare this facility to other projects that might be considered for improving the conveyance of water through the Delta. Improvements to through-Delta conveyance capacities has been described in a recent CALFED report titled *Facilities Descriptions and Updated Cost Estimates for an Improved Through Delta Conveyance Facility* (August 1997).

1.3 Scope of study

This report is primarily concerned with a hydraulic analysis of the isolated facilities canal. The design discharge used in this study is 10,000 cfs. The results described apply generally to canal discharges in the range of 8,000 to 12,000 cfs, and many of the results would also apply to canals in the range of 5,000 to 15,000 cfs. The various elements of the canal are an intake from the Sacramento River, a fish screening facility, the canal, inverted siphons under rivers and other major watercourses, and a pumping plant. The canal's possible role in management of Delta flooding, potential sediment problems, and canal embankment stability are also discussed in this report. The hydraulic analysis of the intake from the Sacramento River and the fish facilities are not covered in this report.

The canal alignment is similar to the original Peripheral Canal alignment and canal alignments used in other studies since that time. Modifications in the canal route have been made in this study at two locations. In the first case, between the Mokelumne River Siphon and the San Joaquin River Siphon the canal alignment has been moved to the east to avoid using siphons at two crossings. In the second case, the alignment of the reach of canal between the San Joaquin River and Clifton Court Forebay has been shifted to the east to avoid an area of deep peat soils.

The vertical profile of the canal as recommended in this report differs from that of earlier studies, however. In this report an "incised canal section" is recommended—that is, the canal cross section that is recommended has the water surface close to the ground surface elevation along the full length of the canal. To accomplish this the canal pumping plant must be located at the downstream end of the canal, near Clifton Court Forebay.

2. EXECUTIVE SUMMARY

This report provides an engineering evaluation of the canal proposed for CALFED Alternative III for Delta water facilities. The canal is similar to the Peripheral Canal proposed in the 1970s. There are some significant differences between the system recommended here and the original Peripheral Canal.

Incised Canal Section

The canal cross section recommended in this report is an "incised section. The canal water surface will at or below the adjacent ground surface. The canal pumping plant must be located at the downstream end of the system to permit the low water surfaces of the incised section. This design concept provides a number of advantages: it allows greater control of seepage from the canal, it permits the possible of receiving excess local flood water into the canal, it minimizes bank stability problems, and it will have low visual impact because the canal embankments will be low in this option

Canal Hydraulics and Operation

Control gates will be incorporated into three inverted-siphon structures: the Mokelumne River, White Slough, and the San Joaquin River Siphons. These check structures will provide greater flexibility in operation of the canal by reducing the time required to make flow changes. Bank instability problems will be minimized by reducing the amount of drawdown of the water surface when large reductions in discharge are made.

River Intake and Fish Facilities

The intake structure at the Sacramento River and the fish screening facility immediately downstream were not dealt with in detail in this report. Various studies of fish screening systems for the diversion are currently underway. Discussing a given design in detail is not appropriate for this report. The intake structure and the fish facility will work in conjunction with each other, and they must be designed as an integrated system.

Sediment Problems

Large quantities of sediment are transported by the Sacramento River and will enter the canal. The construction of sedimentation facilities should be deferred until the actual magnitude of the problem is defined. Land areas for disposal of sediments removed from the canal should be set aside at the start of the project.

Dealing with River and Local Flooding

Potential flood management opportunities exist for the canal recommended in this report. It would be possible to allow floodwater from either Stone Lakes or the Mokelumne system to enter the canal and be carried downstream. The canal control structure at the Mokelumne River Siphon can control the rate and volume of water conveyed, and the maximum rate cannot exceed the design capacity of the canal. The floodwater transported by the canal would have to be pumped (either by the downstream pumping plant at Clifton Court Forebay or into a Delta channel by a pumping plant provided just for that purpose). The floodwaters that would enter the canal are primarily overland

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flows and not flow confined to rivers. Therefore, it is assumed that restrictions on conveyance and release of unscreened diversions would not limit the water from being taken into the canal.

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3. CANAL HYDRAULICS

3.1 Basis of Design

The isolated facility will transport water from the Sacramento River near Hood to the Clifton Court Forebay (CCFB). The forebay is connected to the intake to the Harvey Banks Pumping Plant of the State ~~California~~ Water Project (SWP). Similarly, if the proposed CCFB/Tracy Pumping Plant intertie is constructed, the isolated facility will have the capability to deliver water to the Central Valley Project (CVP) through the Tracy Pumping Plant.

The isolated facility is a large unlined canal that does not release water into Delta channels. The canal will have inverted siphons to carry the water under rivers and other major watercourses that the canal alignment crosses. A headworks structure will be constructed at the intake from the Sacramento River to regulate the flow into the canal under the varying head conditions at the river.

Several design modifications (from the original proposal July 1973) were developed as a result of the hydraulic analysis. In this study, the canal profile involves an incised configuration. The water surface elevation in the canal is close to the ground surface elevation along the alignment of the canal. To accomplish this, the pumping plant must be located at the downstream end of the canal, near CCFB.

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3.2 Pumping Plant Location Options

Two possible locations for the pumping plant were evaluated; the upstream end and the downstream end of the canal. The downstream end of the system was selected as the preferred location. With this configuration, the embankment heights will be minimized. Consequently, this option minimizes seepage from the canal, it provides the capability of receiving excess local flood water into the canal, it minimizes bank stability complications, and it will have a much lower visual impact. These factors are discussed in the following sections.

3.3 Benefits Associated with an Incised Canal Section

Seepage--The original Peripheral Canal design had water surfaces that were more than 10 ft above the natural ground surface for most of the canal route. It was recognized that seepage from the canal would occur, and during the initial years of operation, this seepage would cause problems to lands adjacent to the alignment of the canal. It was assumed that the seepage would decrease with time due to clogging of the soil pores beneath the canal by fine sediment materials suspended in the water. This process has been observed in channels in the Delta. It was understood that this might take many years for the seepage to be reduced to an amount that it did not affect adjacent lands.

The plan for the Peripheral Canal was to provide monetary compensation to farmers and others affected by the seepage for loss of agricultural production and other damages due to the seepage from the canal.

The incised canal cross section assumed for the Isolated Facility canal will have the design water surface near the existing grade adjacent to the canal. At discharges lower than the design discharge, the canal water surface will be lower than the ground surface. The ground water table along much of the canal route is only one or two feet below the ground surface. Thus, the available head to produce seepage for the incised canal cross section will be small and seepage problems associated with this design should be minor.

Potential Flooding Relief--Using an incised cross section provides opportunity for accepting floodwater into the canal and conveying flood water downstream at flow rates up to 10,000 cfs. The canal crosses the outlet channel from Stone Lakes, (which receive flow from the Morrison Stream Group in Sacramento County). This area has frequent flooding problems. These problems can be worsened by the backing up of water from the Cosumnes and Mokelumne Rivers.

There is an opportunity to allow floodwater from either Stone Lakes or the Mokelumne system to enter the canal and be conveyed downstream. The canal control structure at the Mokelumne River Siphon can control the rate and volume of water conveyed downstream. The maximum rate cannot exceed the design capacity of the canal. The floodwater conveyed by the canal would have to be pumped (either by Clifton Court Forebay or into a Delta channel). The floodwaters that would enter the canal are primarily flows that are overland flows and not flow confined to rivers. Therefore, it is assumed that some of the restrictions on conveyance and release of unscreened diversions would not limit the water from being taken into the canal.

Another point to consider is that under existing hydrologic conditions, infrequent flooding will occur in the areas along the canal from Stone Lake to the Mokelumne River. This flooding may produce water levels that are higher than canal embankment elevations. It is recommended that the eastern bank of the canal be constructed to a lower elevation than the western bank. This will permit overland flow to enter the canal and provide an opportunity to pass floodwaters downstream in the canal. Although this type of flooding may cause some minor damage to canal embankments, they should be able to withstand infrequent overtopping much as other embankments in the Delta (such as canal levees, local roads, and Interstate 5).

Bank Stability Considerations--The canal banks for the incised section will be constructed primarily in cut. The maximum fill section will be 8 feet above the ground surface and will have 3:1 sideslopes. Because there will be an excess of excavated material the embankments may be made sufficiently wide to prove a high degree of security against bank failures.

The degree of bank stability provided by an incised canal is high. In contrast, for the option of the pumping plant located at the upstream end of the canal water levels would be over 10 feet higher than adjacent ground elevations. Also, the canal embankments would be a minimum of 15 feet above surrounding ground surfaces. Embankment stability in this case will be of concern. Failure of an embankment could cause flooding and damage to adjacent areas. In contrast, a failure of the embankment for the incised canal might not produce flooding because the canal water surface will be at or below the ground surface.

This is particularly relevant when considering seismic stability issues. The incised section is low and the embankment would not be saturated. The reaised section would have higher embankments and therefore, higer water surface elevations. Furthermore, the lower portionof the embankment may be saturated therreby reducing the structural integrity of the material.

Low Visual Impact--As discussed in the proceeding paragraph the embankments of the incised canal section will extend only a few feet above the adjacent ground surfaces. The embankments will give the same appearance as the roads along the canal alignment. The option using an upstream pumping plant would produce a much greater visual impact and obstruction of sight lines.

3.4 System Components

Fish Facility--A fish screening facility will be incorporated into the intake system to prevent fish from being diverted into the canal. Two types of fish screening facilities are under consideration:

(1) An On-River screen that will allow the fish to remain in the river

(2) An Off-River screening system that will divert some fish from the river with the diverted flow.

Off-river screening will require facilities to return the fish back to the river downstream from the intake, however. The fish screening facilities are not addressed in this report. This report details the facilities required to convey water from immediately downstream of the diversion to CCFB.

Sediment Management--Sediments transported by the Sacramento River will be diverted with the flow, into the proposed canal. As such, measures to deal with this sediment may be needed downstream from the intake.

Pumping Requirements--The energy loss between the diversion point and CCFB requires that pumping be provided to induce flow from the River diversion to the tail of the canal. A pumping plant must be constructed to provide the head to compensate for the energy loss. The pumping plant may be located at any point along the route of the canal. The two most effective locations for a pumping plant are either at the head end (just downstream from the fish facility) or at the downstream end at CCFB. The relative merits of each location are discussed in subsequent sections.

Operational Features—Canal operations are an important part of the canal design process. Operation during normal conditions as well as during emergencies must be considered (emergencies include power failure to the pumping plant, failure of a siphon structure, accommodation of flood flows into the canal, or breaching of the canal embankment).

Design Capacity—This report considers a design discharge for the isolated conveyance facility of 10,000 cfs. Other capacities have been considered, but planning studies indicate that the most probable flow value is in the range of 8,000 to 12,000 cfs. With the exception of specific hydraulic and geometric detail, the discussions in this report regarding a 10,000-cfs facility also apply to other capacities in the range of 5,000 to 15,000 cfs. This report does not consider diversions from the canal. Therefore, a constant 10,000-cfs capacity is assumed for the entire length of the canal. If water is to be diverted at intermediate points along the canal, the dimensions of the canal may be reduced to some extent downstream from the diversion points.

3.5 Canal Section

Section Geometry--The canal cross section geometry proposed in this study is similar to that of the original Peripheral Canal proposal. The lower, main conveyance portion of the cross section is trapezoidal with a flat bottom and 3:1 side slopes (3 horizontal to 1 vertical). At the top of the section the canal is widened with flatter side slopes (8:1) to provide an relatively wide and shallow environmental habitat zone similar to that of a natural channel. The 8:1 sideslopes will also aid in erosion control and improve slope stability of the unlined channel. Figure 3.1 presents the maximum cut and maximum fill canal sections. The maximum side slope value commonly recommended for sandy loam soils is 3:1.

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Channel Roughness Coefficient—A composite Manning's n value for the cross section is assumed to be 0.025 (Chaudhry 1993). Because vegetation will become established on the 8:1 side sections, that portion of the channel will have somewhat higher resistance coefficients than the main portion of the section

A channel with a bottom width of 200 ft and a design depth of 23.5 ft is used in this study. The canal bed slope is 0.00002 ft/ft, and the average velocity at the design discharge of 10,000 cfs is 1.6 ft/sec with a maximum permissible average velocity of 3 ft/sec (Chaudhry 1993).

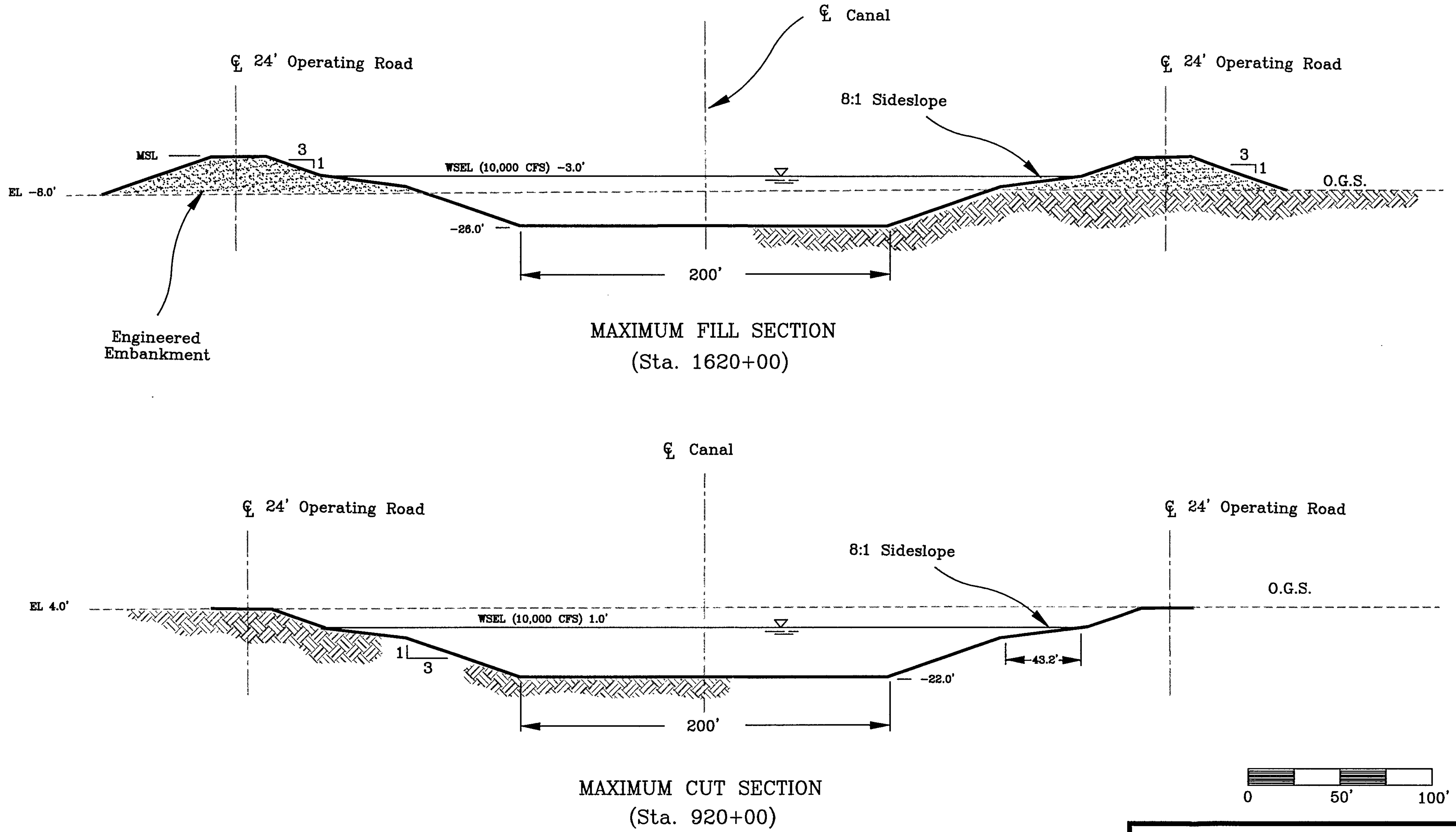

FIGURE 3.1

CALFED BAY-DELTA PROGRAM

ISOLATED FACILITY

MAXIMUM CANAL SECTIONS

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3.6 Inverted Siphons

Eight inverted siphons will be used to cross major waterways along the canal route. The siphon lengths and locations are given in Table 3.1. Each siphon will have four 20-ft-high by 20-ft-wide barrels. At the design discharge of 10,000 cfs, the siphon velocity is 6.25 ft/sec. Figure 3.2 presents a plan, profile, and section of a typical siphon.

Table 3.1

Isolated Facility Siphon Locations and Dimensions

Siphon Name	Location (BS - ES)	Length (Feet)
Stone Lake Siphon	200+00 - 212+00	120
Mokelumne River Siphon	415+00 - 464+00	4,900
Beaver Slough Siphon	662+00 - 665+00	300
White Slough Siphon	1109+00 - 1113+00	400
Disappointment Slough Siphon	1275+00 - 1280+00	500
Fourteen Mile Slough Siphon	1388+00 - 1394+00	600
San Joaquin River Siphon	1490+00 - 1498+00	800
Middle River Siphon	1943+00 - 1951+00	800
Old River Siphon	2267+00 - 2272+00	500

The length of each siphon depends on its location and is a function of the size of the channel that the canal must cross at that location. The governing criterion for determining the siphon lengths was to ensure that the capacities in the natural channels were not reduced. The siphons will have inlet and outlet transitions connecting the closed

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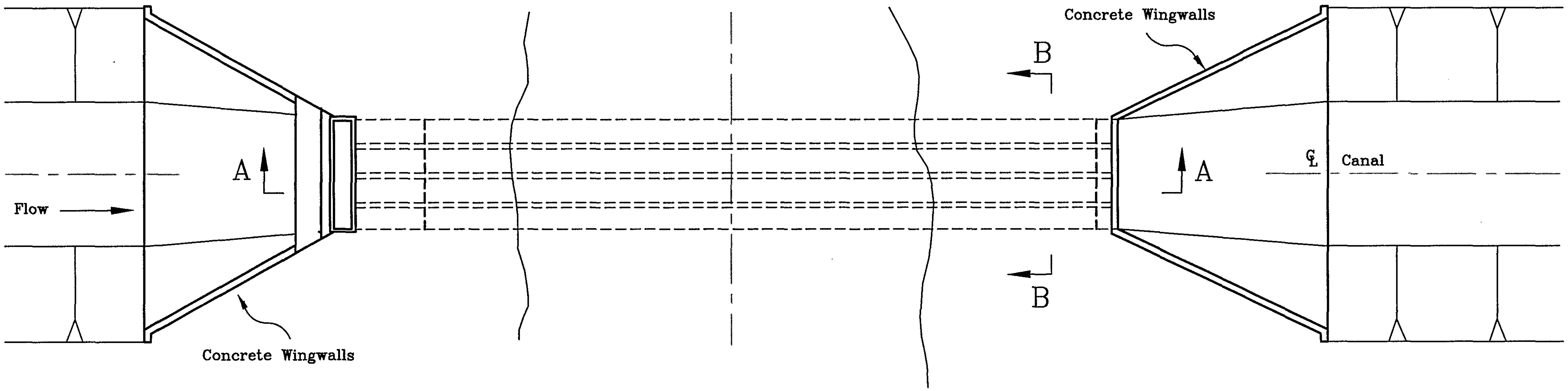
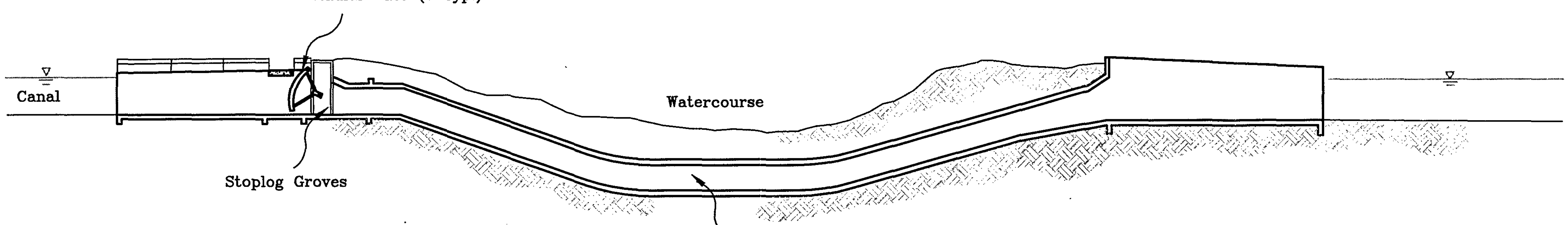


PLAN



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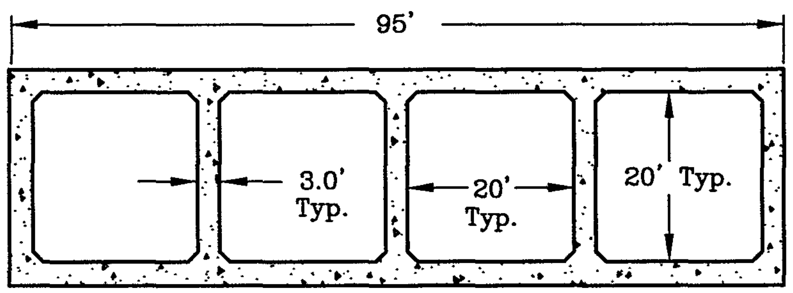

SECTION B–B

FIGURE 3.2

Not To Scale

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ISOLATED FACILITY
TYPICAL SIHPON
GENERAL PLAN AND PROFILE

conduit section to the canal sections upstream and downstream. The change in elevation of the canal invert across the siphon is equal to the siphon headloss at the design discharge.

Except for the longer siphons, the largest portion of the siphon headloss is at the inlet and outlet transitions. Conservative loss coefficients were assumed for these transitions. For a final design, however, optimization of the transition design is required. This could be done using a physical model in a hydraulics laboratory.

3.7 Bridges

Bridges would be constructed at all main county road, state highway, and railroad crossings. These would include State Highway 24, State Highway 12, State Highway 4, Tracy Road, Lambert Road, Laurel Lane, Walnut Grove Road, Peltier Road, Woodbridge Road, Atherton Road, McDonal Road, Calpack Road, Bonatti Road, Middle River Operations and Maintenance Road, Southern Pacific Railroad, Western Pacific Railroad, and Amtrack and San Francisco Railroad main line. Each will have a removable midspan section to permit dredger passage during excavation and maintenance operations.

3.8 Control Structures

The total drop in the hydraulic gradeline (canal water surface) from the upstream end of the canal to the downstream end ranges from 11 feet at 10,000 cfs. to 0.11 at 1,000 cfs. Therefore, check structures are required to regulate the water surface so that the water

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surface downstream from the Sacramento River diversion point is near sea level at the lower diversion rates.

Check structures will reduce some major problems associated with large variations in water level in the canal. These include:

(1) Potential bank instability as a result of large drawdowns in the water surface.

(2) The time required to make a flow change in the canal could be very long, because the change in volume is very large. (For a flow change from 10,000 cfs to 1,000 cfs the volume change is about 6,600 ac-ft, and at a rate of 10,000 cfs it would require 8 hours of pumping to remove this volume of water from the canal.

(3) When the flow is stopped, the volume of water in the flow prism must be removed by discharging the water at the downstream end of the system into CCFB.

Putting control structures at appropriate locations along the canal will allow the water to be ponded in each reach, minimizing the problems listed above. With three check structures, the maximum drawdown in each reach could be kept to 3 to 4 ft. The difference in volume stored in the canal between the maximum and minimum flows would be reduced to 3,000 ac-ft.

Canal control structures will be located at three of the siphons by providing combined siphon-check structures. Gates will be incorporated into the siphon inlets by lengthening

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the rectangular inlet section for these siphons. The additional head loss due to these structures at design flow conditions will be minor, since there will be no need to construct separate inlet and outlet transitions for the gated structures.

Radial gates will be used to adjust flow rates. The gates will be remotely monitored and operated. The gate dimensions will be similar to the dimensions of the gates in the check structures of the North San Joaquin Division of the California Aqueduct. In the California Aqueduct, check structures are also incorporated into some siphon structures.

3.9 Pumping Requirements

The energy losses in the canal from a point downstream from the fish facility to CCFB are about 11 ft at design discharge. This head differential is too large to allow water to flow through the system by gravity. During some periods of the year, the river level may be high enough to provide the necessary head; but during times of maximum delivery through the canal the river level is too low. Therefore, gravity diversion and transport of the flow to CCFB is not feasible, and water conveyed by the canal must be pumped.

The pumping plant could be located at any point along the canal. In this study, it was concluded that the optimal location for the plant is at the downstream end of the canal near Clifton Court Forebay. This location permits the canal water surface elevation to be nearly the same as the ground surface. If the pumping plant were located at the head of

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the canal, the water surface in the canal would be well above the ground elevation along the entire canal alignment.

The incised canal configuration provides a number of benefits. These include:

(1) Less fill material is required;

(2) Seepage from the canal is reduced or eliminated;

(3) Risk and consequences of a levee failure are reduced;

(4) Possible reduction of Delta flooding by taking flood waters into the canal.

The original Peripheral Canal design (DWR 1973) incorporated a pumping plant with about the same static lift as the pumping lift described in this report. The conceptual design of the original Peripheral Canal pumping plant is appropriate based on mechanical, structural, and soil considerations. Therefore, the basic design of this plant can also be used for the canal described in this report also. A cross section of the pumping plant is shown in Figure 3.3.

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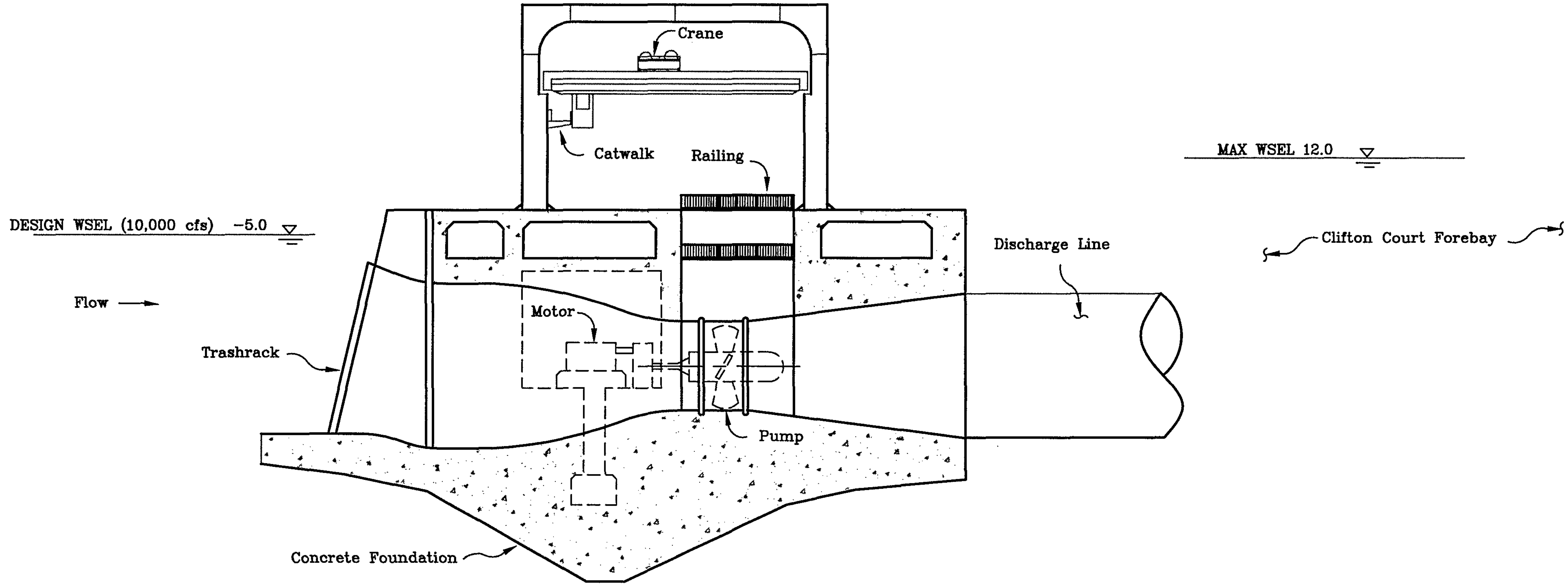

Not To Scale

FIGURE 3.3

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ISOLATED FACILITY

PUMPIING PLANT SECTION

3.10 Facilities Inventory

A summary of the facilities described above is presented in table 3.2.

TABLE 3.2
Facilities Inventory

REACH	STATIONING	ITEM	QUANTITY	UNITS
1	140+00 - 464+00			
		Canal	32,280	LF
		Stone Lake Siphon	120	LF
		Mokelumne Control Structure	4 20' X 20' Radial Gates	
		Mokelumne River Siphon	4,900	LF
2	464+00 - 1113+00			
		Canal	64,200	LF
		Beaver Slough Siphon	300	LF
		White Slough Control Structure	4 20' X 20' Radial Gates	
		White Slough Siphon	400	LF
3	1113+00 - 1498+00			
		Canal	37,100	LF
		Fourteen Mile Slough Siphon	600	LF
		San Joaquin River Control Structure	4 20' X 20' Radial Gates	
		San Joaquin River Siphon	800	LF
4	1498+00 - 1951+00			
		Canal	44,500	LF
		Middle River Control Structure	4 20' X 20' Radial Gates	
		Middle River Siphon	800	LF
5	1951+00 - 2272+00			
		Canal	31,600	LF
		Old River Siphon	500	LF
		Clifton Court Pumping Plant	24,000*	HP

* 10,00 cfs, Total Dynamic Head = 16 feet

3.11 Hydraulic Analysis

Steady Flow Model of Canal—Canal hydraulic conditions were modeled using computer program HEC-RAS (Hydrologic Engineering Center, 1997). HEC-RAS is a one-dimensional steady-state-open-channel-flow computer model. It provides a convenient and accurate method of computing water surface profiles in the system. Multiple profiles can be analyzed in a single computer run allowing conditions at the design discharge to be compared with other discharges.

The inverted siphons are represented in the model using the culvert routines of the program. The operation of the check structures is represented by specifying the canal water surface elevation value at the structure.

HEC-RAS has a variety of graphical output features. A profile plot of the entire canal is shown in Figure 3.4. Various tables of results are also available. Table 3.3 shows the water surface elevations and other data for three different discharges analyzed by the program. The profiles for canal discharges that are less than the design discharge are assumed to be regulated by the control structures.

ISOLATED FACILITY CANAL PROFILE

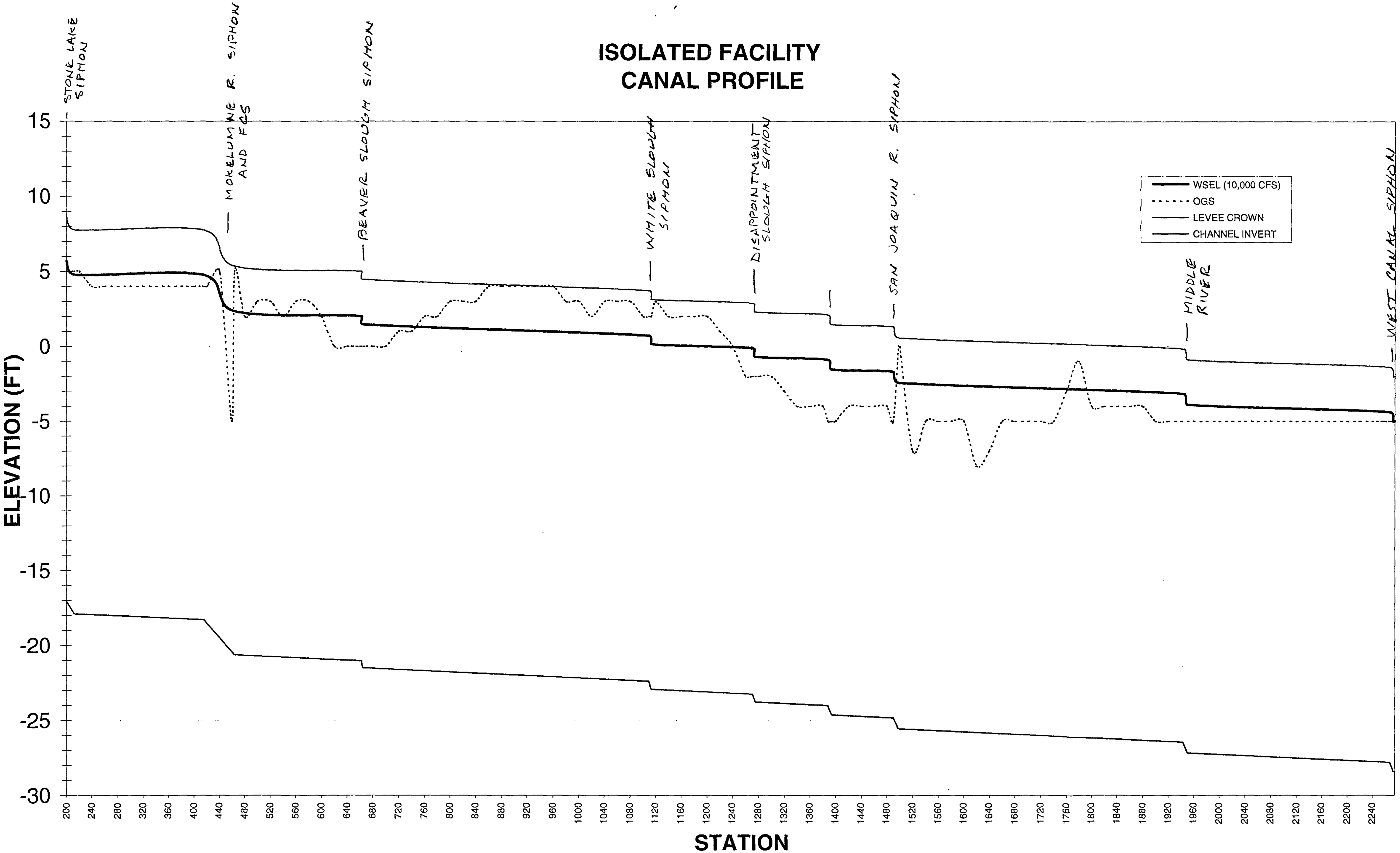

FIGURE 3.4

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TABLE 3.3
Summary of Hydraulic Parameters

REACH REACH	RIVER STATION	TOTAL FLOW	MIN CHANNEL ELEVATION	W.S. ELEVATION	MAX CHANNEL ELEVATION	E.G. ELEVATION	E.G. SLOPE	CHANNEL VELOCITY	FLOW AREA	TOP WIDTH
		(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)
Reach 1	100	10000.00	-16.84	5.86	22.70	5.90	0.000018	1.61	6196.90	383.22
Reach 1	100	5000.00	-16.84	1.35	18.19	1.36	0.000009	1.08	4629.66	310.98
Reach 1	100	2500.00	-16.84	0.10	16.94	0.11	0.000003	0.59	4249.24	301.65
Reach 1	100	100.00	-16.84	-5.00	11.84	-5.00	0.000000	0.04	2789.09	271.05
Reach 1	200	10000.00	-17.04	5.68	22.72	5.72	0.000018	1.61	6203.83	383.51
Reach 1	200	5000.00	-17.04	1.25	18.29	1.27	0.000009	1.07	4663.50	312.72
Reach 1	200	2500.00	-17.04	0.07	17.11	0.08	0.000003	0.58	4300.94	302.67
Reach 1	200	100.00	-17.04	-5.00	12.04	-5.00	0.000000	0.04	2843.38	272.25
Stone Lake Siphon										
Reach 1	212	10000.00	-17.88	4.78	22.66	4.82	0.000018	1.62	6182.65	382.63
Reach 1	212	5000.00	-17.88	1.01	18.89	1.03	0.000008	1.03	4852.99	322.27
Reach 1	212	2500.00	-17.88	0.00	17.88	0.01	0.000002	0.55	4536.13	307.30
Reach 1	212	100.00	-17.88	-5.00	12.88	-5.00	0.000000	0.03	3074.11	277.29
Reach 1	415	10000.00	-18.28	4.76	23.04	4.80	0.000017	1.58	6327.01	388.62
Reach 1	415	5000.00	-18.28	1.00	19.28	1.02	0.000008	1.00	4979.35	328.48
Reach 1	415	2500.00	-18.28	0.00	18.28	0.00	0.000002	0.54	4658.87	312.48
Reach 1	415	100.00	-18.28	-5.00	13.28	-5.00	0.000000	0.03	3185.50	279.69
Mokelumne River Siphon										

TABLE 3.3
Summary of Hydraulic Parameters

REACH REACH	RIVER STATION	TOTAL FLOW	MIN CHANNEL ELEVATION	W.S. ELEVATION	MAX CHANNEL ELEVATION	E.G. ELEVATION	E.G. SLOPE	CHANNEL VELOCITY	FLOW AREA	TOP WIDTH
		(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)
Reach 2	464.22	10000.00	-20.63	2.35	22.98	2.39	0.000017	1.59	6303.42	387.65
Reach 2	464.22	5000.00	-20.63	0.47	21.10	0.48	0.000006	0.89	5604.07	357.62
Reach 2	464.22	2500.00	-20.63	-0.87	19.76	-0.86	0.000002	0.49	5140.15	336.22
Reach 2	464.22	100.00	-20.63	-5.00	15.63	-5.00	0.000000	0.03	3859.21	293.79
Beaver Slough Siphon										
Reach 2	662	10000.00	-21.03	2.01	23.04	2.05	0.000017	1.58	6327.35	388.63
Reach 2	662	5000.00	-21.03	0.36	21.39	0.37	0.000006	0.88	5707.22	362.20
Reach 2	662	2500.00	-21.03	-0.90	20.13	-0.90	0.000002	0.47	5264.07	342.07
Reach 2	662	100.00	-21.03	-5.00	16.03	-5.00	0.000000	0.03	3977.17	296.19
Reach 2	664	10000.00	-21.50	1.47	22.97	1.51	0.000017	1.59	6301.79	387.58
Reach 2	664	5000.00	-21.50	0.23	21.73	0.24	0.000005	0.86	5830.32	367.60
Reach 2	664	2500.00	-21.50	-0.93	20.57	-0.93	0.000002	0.46	5415.12	349.06
Reach 2	664	100.00	-21.50	-5.00	16.50	-5.00	0.000000	0.02	4117.02	299.01
Reach 2	1109	10000.00	-22.40	0.72	23.12	0.76	0.000017	1.57	6358.18	389.90
Reach 2	1109	5000.00	-22.40	0.00	22.40	0.01	0.000005	0.82	6082.08	378.40
Reach 2	1109	2500.00	-22.40	-1.00	21.40	-1.00	0.000001	0.44	5711.68	362.40
Reach 2	1109	100.00	-22.40	-5.00	17.40	-5.00	0.000000	0.02	4388.49	304.40
White Slough Siphon										

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TABLE 3.3
Summary of Hydraulic Parameters

REACH REACH	RIVER STATION	TOTAL FLOW	MIN CHANNEL ELEVATION	W.S. ELEVATION	MAX CHANNEL ELEVATION	E.G. ELEVATION	E.G. SLOPE	CHANNEL VELOCITY	FLOW AREA	TOP WIDTH
		(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)
Reach 3	1113	10000.00	-22.93	0.15	23.08	0.19	0.000017	1.58	6342.75	389.27
Reach 3	1113	5000.00	-22.93	-1.32	21.61	-1.30	0.000005	0.86	5789.54	365.82
Reach 3	1113	2500.00	-22.93	-1.68	21.25	-1.67	0.000001	0.44	5658.33	360.04
Reach 3	1113	100.00	-22.93	-5.00	17.93	-5.00	0.000000	0.02	4550.65	307.58
Reach 3	1271	10000.00	-23.25	-0.12	23.13	-0.08	0.000017	1.57	6364.06	390.14
Reach 3	1271	5000.00	-23.25	-1.40	21.85	-1.39	0.000005	0.85	5876.26	369.59
Reach 3	1271	2500.00	-23.25	-1.70	21.55	-1.70	0.000001	0.43	5766.29	364.80
Reach 3	1271	100.00	-23.25	-5.00	18.25	-5.00	0.000000	0.02	4649.67	312.01
Disappointmet Slough Siphon										
Reach 3	1275	10000.00	-23.78	-0.69	23.09	-0.65	0.000017	1.58	6348.61	389.51
Reach 3	1275	5000.00	-23.78	-1.54	22.24	-1.53	0.000005	0.83	6021.11	375.81
Reach 3	1275	2500.00	-23.78	-1.74	22.04	-1.73	0.000001	0.42	5948.73	372.72
Reach 3	1275	100.00	-23.78	-5.00	18.78	-5.00	0.000000	0.02	4817.27	320.49
Reach 3	1388	10000.00	-24.01	-0.88	23.13	-0.84	0.000017	1.57	6364.42	390.16
Reach 3	1388	5000.00	-24.01	-1.60	22.41	-1.59	0.000005	0.82	6087.13	378.61
Reach 3	1388	2500.00	-24.01	-1.75	22.26	-1.75	0.000001	0.41	6029.57	376.17
Reach 3	1388	100.00	-24.01	-5.00	19.01	-5.00	0.000000	0.02	4891.39	324.17
Fourteen Mile Slough										
Reach 3	1394	10000.00	-24.64	-1.53	23.11	-1.49	0.000017	1.57	6356.35	389.82

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TABLE 3.3
Summary of Hydraulic Parameters

REACH REACH	RIVER STATION	TOTAL FLOW	MIN CHANNEL ELEVATION	W.S. ELEVATION	MAX CHANNEL ELEVATION	E.G. ELEVATION	E.G. SLOPE	CHANNEL VELOCITY	FLOW AREA	TOP WIDTH
		(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)
Reach 3	1394	5000.00	-24.64	-1.76	22.88	-1.75	0.000004	0.80	6266.10	386.10
Reach 3	1394	2500.00	-24.64	-1.79	22.85	-1.79	0.000001	0.40	6254.13	385.61
Reach 3	1394	100.00	-24.64	-5.00	19.64	-5.00	0.000000	0.02	5098.77	334.25
Reach 3	1490	10000.00	-24.84	-1.69	23.15	-1.65	0.000017	1.57	6371.84	390.46
Reach 3	1490	5000.00	-24.84	-1.80	23.04	-1.79	0.000004	0.79	6327.53	388.64
Reach 3	1490	2500.00	-24.84	-1.80	23.04	-1.80	0.000001	0.40	6327.53	388.64
Reach 3	1490	100.00	-24.84	-5.00	19.84	-5.00	0.000000	0.02	5165.93	337.45
San Joaquin River Siphon										
Reach 4	1498	10000.00	-25.56	-2.42	23.14	-2.38	0.000017	1.57	6367.22	390.27
Reach 4	1498	5000.00	-25.56	-4.28	21.28	-4.27	0.000006	0.88	5668.35	360.48
Reach 4	1498	2500.00	-25.56	-4.81	20.75	-4.81	0.000002	0.46	5477.84	351.92
Reach 4	1498	100.00	-25.56	-5.00	20.56	-5.00	0.000000	0.02	5413.01	348.96
Reach 4	1943	10000.00	-26.46	-3.15	23.31	-3.11	0.000016	1.56	6433.87	392.99
Reach 4	1943	5000.00	-26.46	-4.52	21.94	-4.51	0.000005	0.85	5909.13	371.01
Reach 4	1943	2500.00	-26.46	-4.88	21.58	-4.88	0.000001	0.43	5777.40	365.29
Reach 4	1943	100.00	-26.46	-5.00	21.46	-5.00	0.000000	0.02	5733.52	363.36
Middle River Siphon										
Reach 5	1951	10000.00	-27.18	-3.88	23.30	-3.84	0.000016	1.56	6429.09	392.80
Reach 5	1951	5000.00	-27.18	-4.70	22.48	-4.69	0.000005	0.82	6111.10	379.63
Reach 5	1951	2500.00	-27.18	-4.92	22.26	-4.92	0.000001	0.41	6027.47	376.08

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TABLE 3.3
Summary of Hydraulic Parameters

REACH REACH	RIVER STATION	TOTAL FLOW	MIN CHANNEL ELEVATION	W.S. ELEVATION	MAX CHANNEL ELEVATION	E.G. ELEVATION	E.G. SLOPE	CHANNEL VELOCITY	FLOW AREA	TOP WIDTH
		(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)
Reach 5	1951	100.00	-27.18	-5.00	22.18	-5.00	0.000000	0.02	5999.26	374.88
Reach 5	2267	10000.00	-27.81	-4.38	23.43	-4.35	0.000016	1.55	6478.55	394.81
Reach 5	2267	5000.00	-27.81	-4.85	22.96	-4.84	0.000004	0.79	6297.79	387.41
Reach 5	2267	2500.00	-27.81	-4.96	22.85	-4.96	0.000001	0.40	6253.33	385.57
Reach 5	2267	100.00	-27.81	-5.00	22.81	-5.00	0.000000	0.02	6238.59	384.96
Old River Siphon										
Reach 6	2272	10000.00	-28.39	-5.00	23.39	-4.96	0.000016	1.55	6466.41	394.32
Reach 6	2272	5000.00	-28.39	-5.00	23.39	-4.99	0.000004	0.77	6465.00	394.26
Reach 6	2272	2500.00	-28.39	-5.00	23.39	-5.00	0.000001	0.39	6464.65	394.24
Reach 6	2272	100.00	-28.39	-5.00	23.39	-5.00	0.000000	0.02	6464.54	394.24
Reach 6	2275	10000.00	-28.40	-5.00	23.40	-4.96	0.000016	1.55	6468.48	394.40
Reach 6	2275	5000.00	-28.40	-5.00	23.40	-4.99	0.000004	0.77	6468.48	394.40
Reach 6	2275	2500.00	-28.40	-5.00	23.40	-5.00	0.000001	0.39	6468.48	394.40
Reach 6	2275	100.00	-28.40	-5.00	23.40	-5.00	0.000000	0.02	6468.48	394.40

3.12 Canal Operation

Two types of operation of the system must be evaluated: normal operation and emergency operation.

Normal Operation—The canal is expected to be operated to convey water from the Sacramento River to Clifton Court Forebay at a constant rate for periods of time that would last for several days. Flow changes will be in relatively small increments and will be scheduled in advance. A remote-manual control system (as used for the California Aqueduct system) is appropriate for operating this canal. No turnouts are currently planned for the canal; what is diverted from the river is conveyed directly to CCFB. The check structure gates will be operated in coordination with flow diverted from the river and pumped at the pumping plant. Water level and gate position sensors will allow the operators to continuously monitor and evaluate flow conditions.

Emergency Operation—There will be circumstances in which unplanned conditions will occur; these may include a power failure at the pumping plant, a breach of the canal section, or problems at the diversion and fish screening facility. Under these conditions, the canal must be shut down as rapidly as possible, holding the water in transit in storage in the canal reaches. The gates in the check structures would be rapidly closed to isolate each canal reach. Additionally, the pumping plant would be shut down.

The hydraulic conditions that occur during a rapid shut down require simulation by a computer model using the full equations of unsteady open channel flow. This simulation will provide data on the variations in the water levels that will occur during the emergency shut down. These water levels may affect the selection of freeboard height for the canal section at the pumping plant.

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4. FISH FACILITIES

A fish screening facility must be located at the intake from the Sacramento River as mention above. Various types of screens are appropriate for this facility. Currently, the agencies responsible for fish screen criteria are planning to use an inverted-vee type of screening system at this location (Ref.). One of the major requirements for effective screening of fish is the need for uniform velocity distributions at the screen. Uniform velocity distributions must exist for all rates of diversion through the screens. A sophisticated control system at the diversion will be required to maintain steady and uniform flows at the screens as river flow rates and water levels change with time. The downstream pumping plant will not directly affect the hydraulic conditions at the screen structure. In most cases steady flow conditions will exist in the canal downstream from the fish screen structure. The control structures along the canal will regulate water surface levels throughout the system. Therefore, the canal water levels will remain steady during operational flow changes in the canal.

Fish return facilities will be needed for any off river screen system. The hydraulic analysis of the fish return system is beyond the scope of this study, but it seems very unlikely that any system can be devised that does not require pumping of the fish to return them to the river.

There will be no opportunity to remove sediment from the diverted flow until the flow has passed through the fish screen system. To minimize the entry of sediment into the canal, the intake design should be carefully evaluated. Hydraulic model studies should be undertaken to develop an intake configuration that keeps bed load sediments in the river. Potential sediment problems are discussed in the next section.

5. SEDIMENT PROBLEMS

5.1 Need for a Sedimentation Basin

The magnitude of problems associated with deposition of sediments in the canal is difficult to quantify. Sedimentation will occur in the canal because the Sacramento River transports very large quantities of sediment in the form of both bed load and suspended load. It is assumed that the design of the intake can be optimized to exclude most of the bed load sediments from entering the diversion structure and fish screens. The design should be based on hydraulic laboratory modeling as well as analytical procedures. Sediment that is carried as suspended load will be diverted with the water. Some of this material will be deposited in the canal when canal velocities are low. During much of the time, the canal velocities will be high enough to keep the sediment particles suspended in the flow and the sediment will be transported to CCFB. If there is sediment deposition, it will occur in the initial portion of the canal.

Sedimentation problems were studied in the design of the Peripheral Canal. A sedimentation basin was discussed in the 1973 report. However, because its precise needs were not known, it was decided that construction of the sedimentation basin for the Peripheral Canal should be deferred until the magnitude of the sediment problem was determined through operation of the canal.

Deferral of construction of a sedimentation basin is recommended for the Isolated Facility also. A sedimentation basin may not be needed. The canal cross section is very large and some deposition of material can occur before the capacity is affected to a significant degree. It may be possible to allow the initial reach of the canal to act as a sediment basin, and removal of the deposited material could be accomplished by dredging. A small floating dredge could easily operate in the canal, and sediment could be removed as it accumulates.

If necessary, a sediment basin could be constructed after the canal is in operation as an in-line basin by adding a parallel channel to the canal. To cause sediment to deposit the flow velocity must be sufficiently low and the length of the flow path sufficiently long to allow sediment particles to settle out. Having parallel channels could allow one settling basin to be cleaned while the other is kept in operation.

5.2 Disposal of Sediment

An area set aside for the disposal of sediment removed from the canal will be needed no matter what type of sedimentation scheme is used. The volume of material that must be disposed of over the life of the canal will be large. Adequate space should be set aside for this. A drainage system for dewatering of the dredged material must be provided. Once the material is dry, it may be suitable for use in levee strengthening or for filling low areas in the Delta.

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6. RIVER AND LOCAL FLOODING CONSIDERATIONS

6.1 River Flooding Considerations

The canal will cross major rivers carrying flow into the Delta as well as a number of drainage channels and sloughs that are less critical for flood conveyance. In addition, ground elevations along the entire route of the canal are near or below sea level. Therefore, during periods of flooding the entire canal may be inundated by floodwaters. There are two primary problems to be dealt with:

(1) conveying local runoff past the canal

(2) allowing major river crossings to carry flood water past the canal

6.2 Dealing with Local Runoff

The canal will be constructed across Delta islands which normally do not gravity drainage to a river or slough. Drainage of the Delta islands is usually accomplished by pumping from a drainage ditch that collects both surface runoff and subsurface drainage for water table control. Drainage ditches along the canal embankments to intercept local runoff will be connected to existing drainage channels in the islands.

6.2 Major Stream Crossings

As discussed above, inverted siphons will be used at the crossings of major streams and sloughs. The basic stream waterway dimensions will be retained at these crossings to maintain floodway capacity and to not impede boating passage.

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6.3 Operation of System during Major Floods

As previously mentioned, it may be possible to use the canal to convey floodwaters during extreme flood events to relieve flooding problems in the Beach and Stone Lakes and Mokelumne River crossing areas. Water introduced into the canal would be pumped out of the canal. If no specific additional pumping facilities for floodwater pumping are provided, the water allowed to enter the canal would be pumped into CCFB. This water could be stored in CCFB, pumped into the California Aqueduct or Delta-Mendota Canal, or released into Delta channels.

7. CONCLUSIONS

The Isolated Delta Conveyance Canal can be constructed to provide the desired function of transfer of water across the Delta. The canal could als be used for flood management and to provide water supply in the Delta. The canal described in this report differs in several ways from the original Peripheral Canal. The major differences involve placing the pumping at Clifton Court Forebay and using control structures in the canal. Tis design results in an incised canal section (in contrast to the raised canal). A comparison of the primary benefits and drawbacks relative to the two canal configurations is shown in Table 7.1.

A pumping plant located at the downstream end of the system provides control of seepage from the canal, it permits the possible of receiving excess local flood water into the canal, it minimizes bank stability problems, and it will have a low visual impact because the canal embankments will be low.

Using radial gate check structures at three of the siphon structures will greatly increase operational control and flexibility.

Sediment problems will be present, but construction of a sedimentation basin can be deferred until the sedimentation problem is better defined.

The design presented in this report provides opportunity to allow floodwater from either Stone Lakes or the Mokelumne system to enter the canal and be conveyed downstream. The canal control structure at the Mokelumne River Siphon can control the rate and

TABLE 7.1
Comparison of Incised Canal and Raised Canal

ITEM	INCISED CANAL	RAISED CANAL
Seepage	Minimal seepage, canal water level near groundwater table	Extensive seepage that may affect adjacent land
Potential Flooding Due to Canal Breaching	Minimal risk -- canal water surface near ground surface[1]	High risk -- canal water surface greater than 10 feet above ground surface
Bank Stability	Low embankments -- low water surface on embankment	High embankment, high water surface for saturation of embankments
Flooding Relief	Floodwaters can be accepted into the canal	Floodwaters must be pumped into the canal
Disposal of Flood Water	Conveyed to South Delta and pumped into CCFB or released into delta channels	Capability of gravity release to Delta channels downstream from River diversions
Sediment Management	Sediment can deposit in initial reaches of canal	Sediment passes through pumping plant
Emergency Operation	All water kept or below surface for full shutdown	Water in canal must be ponded above ground level
Hydraulic Control	Requires flow control gate downstream of fish screens	Pumping plant downstream of fish screens
Fish Screening Facilities	Requires sophisticated gate control system	Pumping plant provides flow control through screens
Pumping Plant Location	Questionable foundation material, but foundation may be below peat	Adequate foundation condition
Visual Impacts	Low embankments, similar to existing levee and road heights	High embankments (higher than other local feature)

1 This issue is particularly relevant to seismic stability.

volume of water conveyed downstream. The maximum rate cannot exceed the design capacity of the canal. The floodwater conveyed by the canal would have to be pumped either by the canal pumping plant into Clifton Court Forebay or into a Delta channel.

8. REFERENCES

CALFED Bay-Delta Program, January 1996, *Preliminary Evaluation of 5,000 cfs Isolated Facility Using Buried Pipeline.*

CALFED Bay-Delta Program, August 1997, *Facility Descriptions and Updated Cost Estimates for an Improved Through Delta Conveyance Facility.*

California Department of Water Resources, July 1973, *Peripheral Canal – Preliminary Design Report.*

California Department of Water Resources, August 1974, *Draft Environmental Impact Report - Peripheral Canal Project.*

California Department of Water Resources, July 1978, *Delta Water Facilities—Bulletin 76.*

California Department of Water Resources, November 1983, *Alternatives for Delta Water Transfer.*

California Department of Water Resources, November 1993, *Program Environmental Impact Report - State Drought Water Bank.*

California Department of Water Resources, September 1995, *Cost Estimate - Isolated Transfer Facility.*

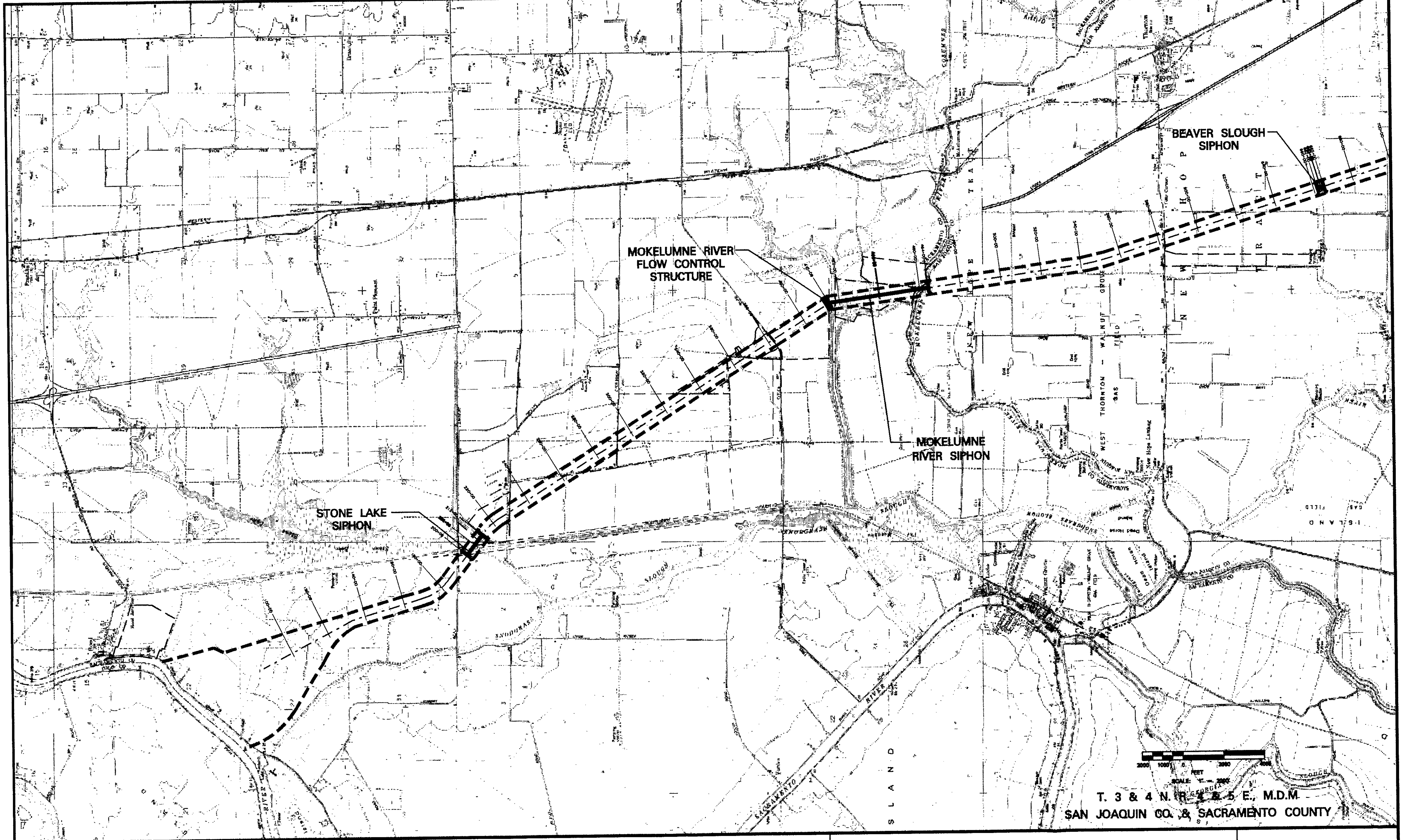
Chaudhry, M.H., 1993, Open Channel Flow, Prentice-Hall, Englewood Cliffs, N.J.

U.S. Bureau of Reclamation, October 1964, *Reconnaissance Estimate, Delta Division - Peripheral Canal*, Department of the Interior.

U.S. Fish and Wildlife Service, September 1995, *Environmental Effects of Yield Increase Options, Technical Appendix 9 to the Final Least-Cost CVP Yield Increase Plan.*

APPENDIX A

ISOLATED FACILITY ALIGNMENT



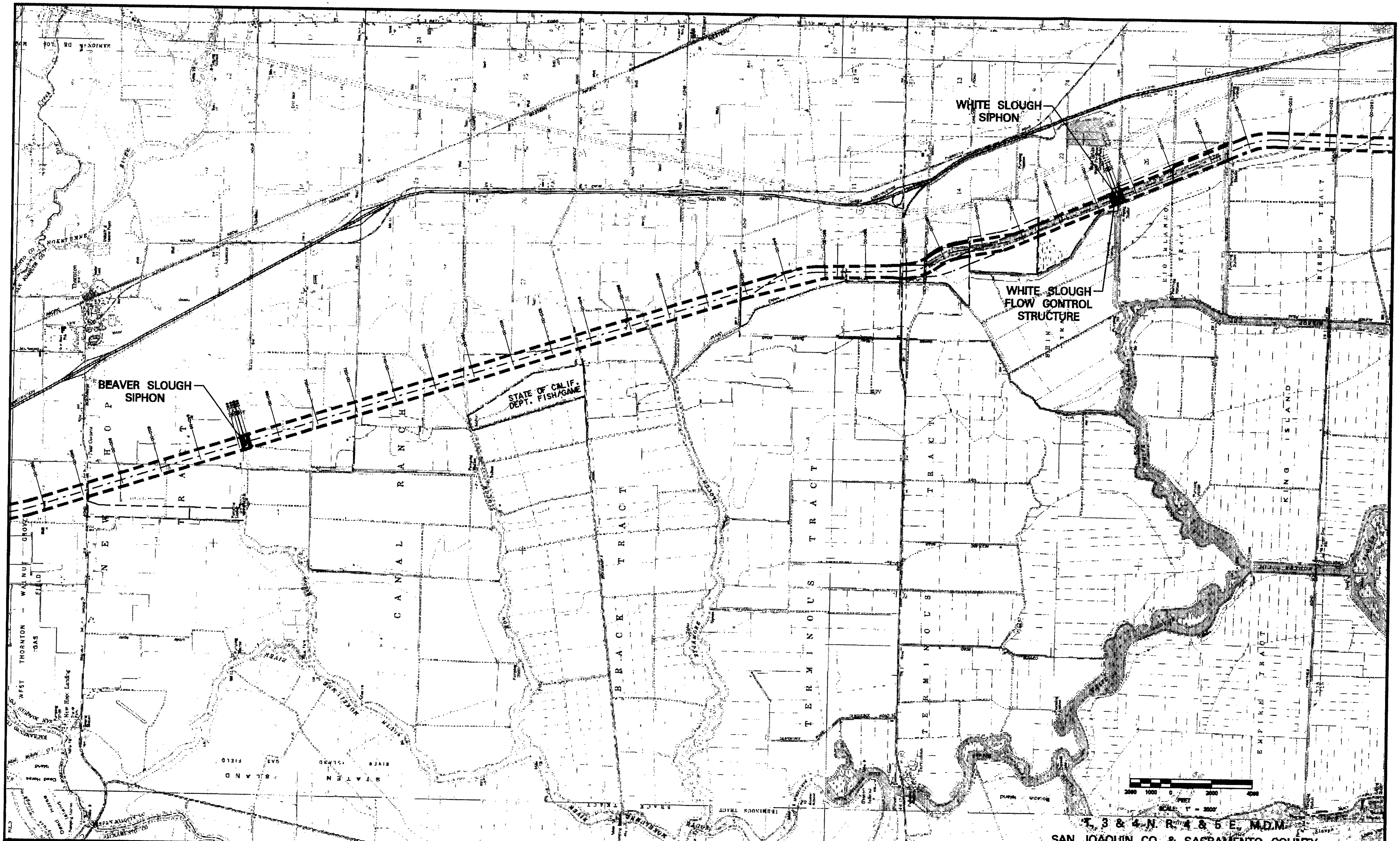
N

CALFED
BAY – DELTA PROGRAM

ISOLATED DELTA CHANNEL
PROPOSED ALIGNMENT

SHEET 1 OF 4

D-011044



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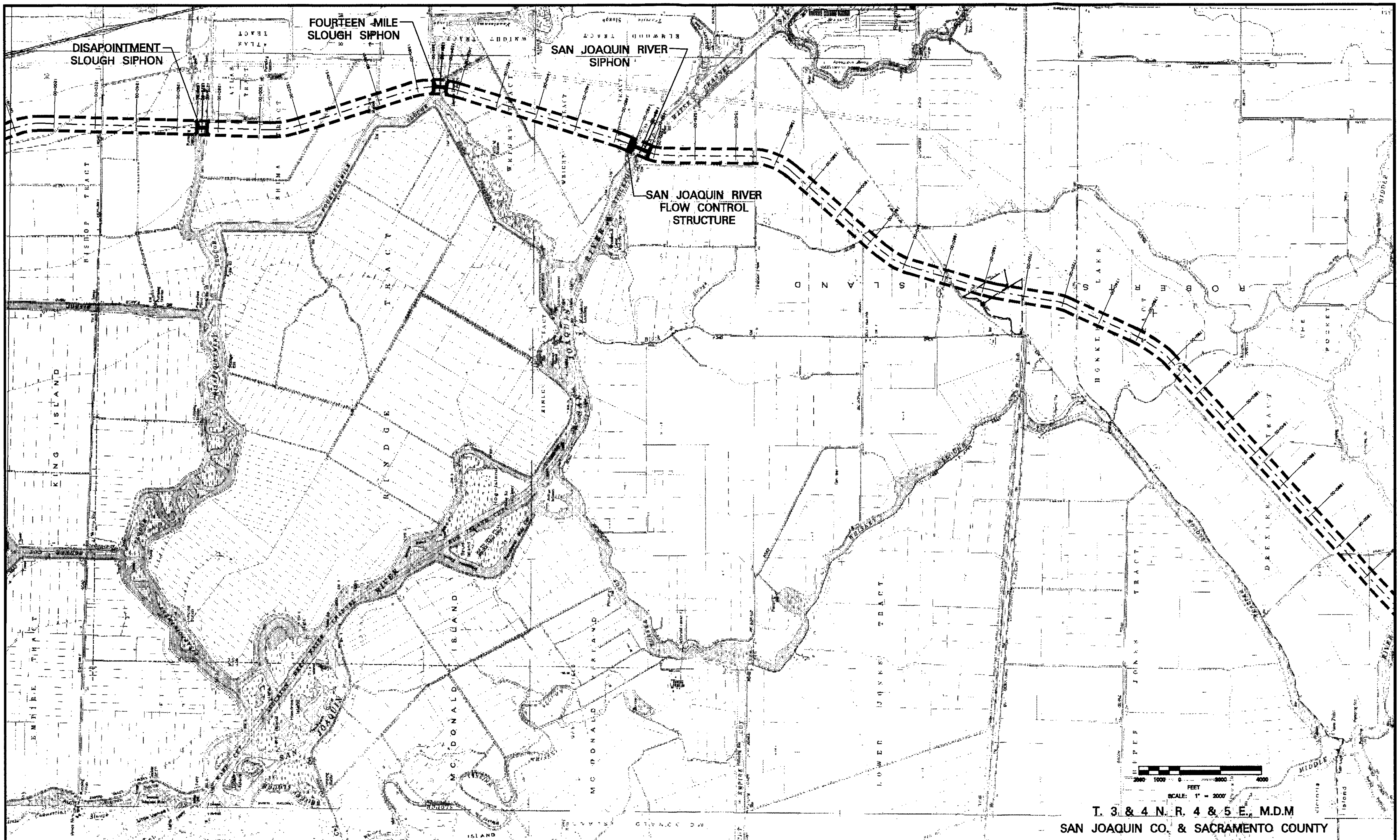
CALFED
BAY - DELTA PROGRAM

ISOLATED DELTA CHANNEL
PROPOSED ALIGNMENT

SHEET 2 OF 4

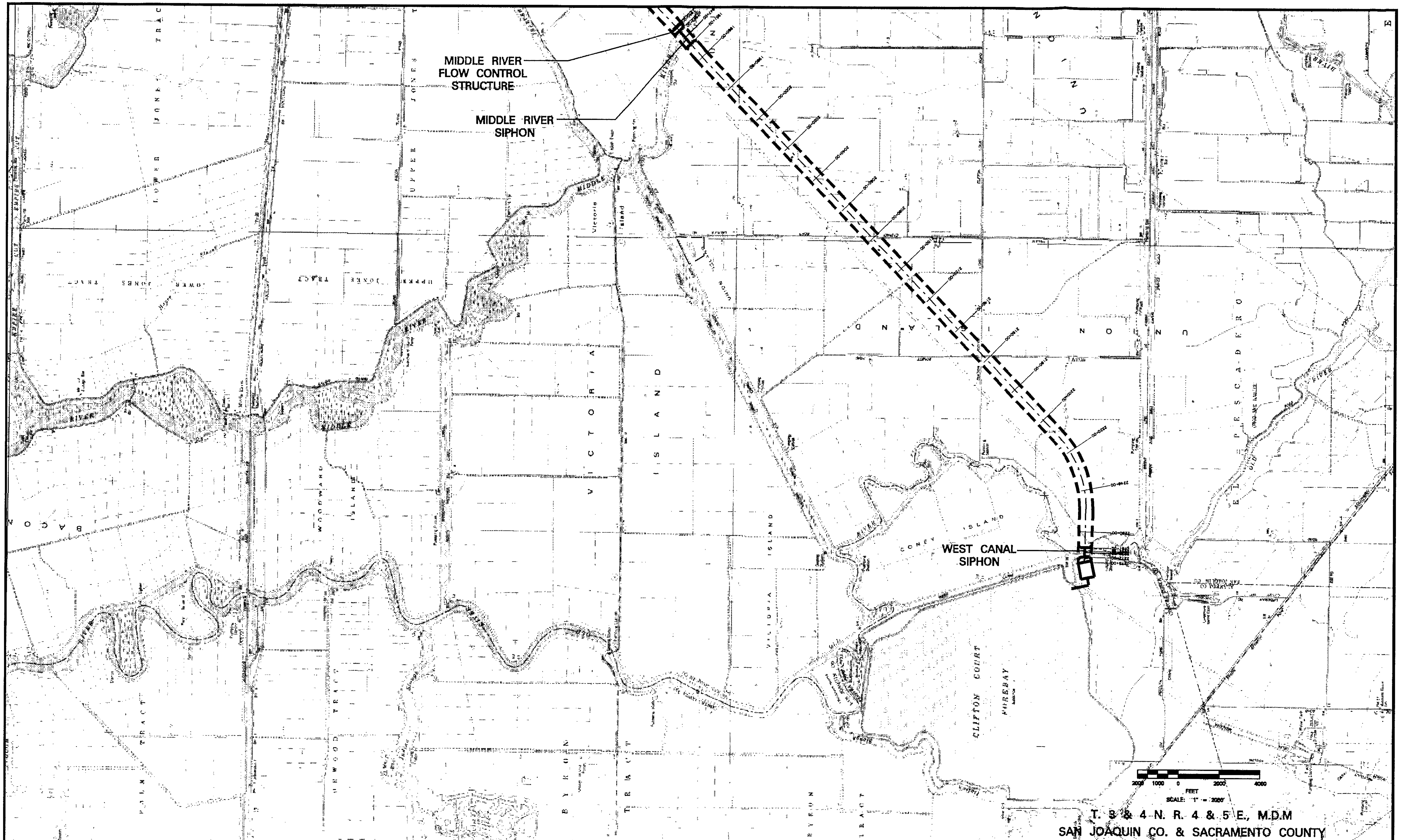
D—011044



N	CALFED BAY - DELTA PROGRAM	ISOLATED DELTA CHANNEL PROPOSED ALIGNMENT	SHEET 3 OF 4

D-011045

D-011045



CALFED
BAY – DELTA PROGRAM

ISOLATED DELTA CHANNEL
PROPOSED ALIGNMENT

SHEET 4 OF 4

D–011046